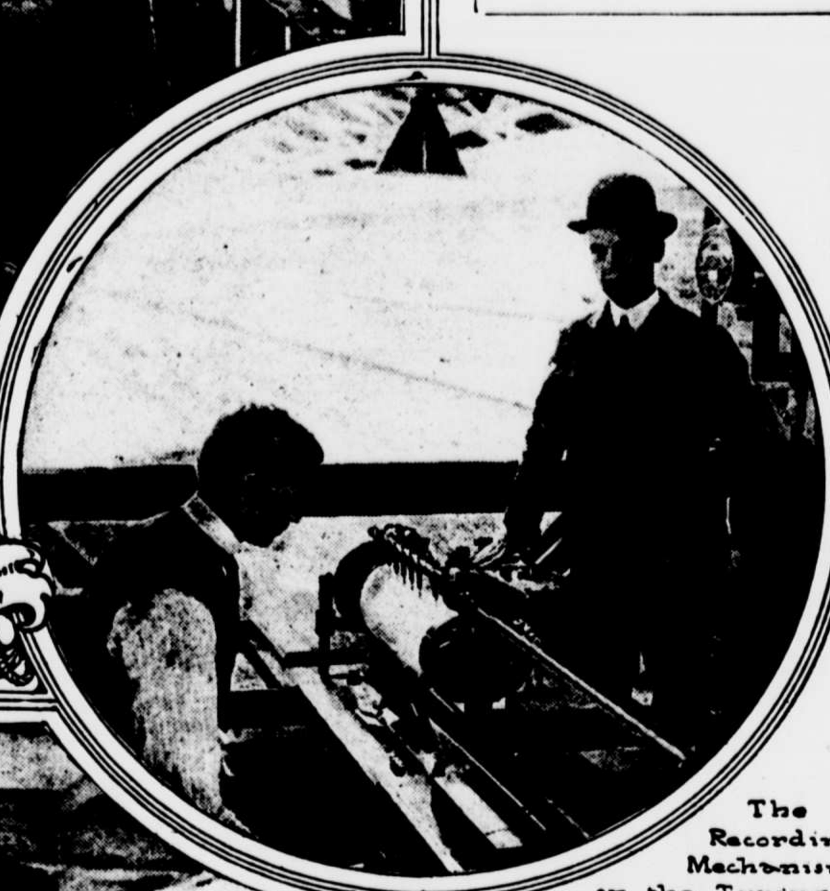
MINIATURE WARSHIPS TESTED IN A MODEL TANK

Loading the Model with Bags of Shot to Proper Displacement

Making and Testing Models of Proposed Warships



The Recording Mechanism on the Towing Carriage

The Model Making Machine

Growing Speed of Naval Vessels Due Largely to Tests Made in an Experiment Basin in Washington—Device Saves Millions

YOU have taken a patriotic pride in the speed performances of American fighting ships, and if you have followed these showings closely you have no doubt been impressed with the steady advance made. Each year naval vessels have shown consistent improvement in speed, seaworthiness and engineering economy, but have you ever paused to ask how these results are primarily made possible? This is the direct fruit of the model experimental basin.

The model tank, as it is generally called for brevity's sake, is the establishment in which small models of prospective ships are made and tried on a reduced scale. When Congress was asked to appropriate money for the plant which is now an interesting and important department of the navy yard at Washington the proposition was looked upon as involving an expensive toy. Since then, however, the work done there preliminary to the building of warships has represented a saving of many hundreds of thousands of dollars, besides insuring the designed performance of the man-of-war.

This is another example of the old rule of thumb being supplanted by the certainties of science. Without going too far into the history of things it is sufficient to know that an Englishman, Dr. William Froude, discovered back in the '70s that there was a comparable relation between the power required to draw a small model through the water and the motive energy needed to propel a big craft of similar form. The principle which he discovered later became known as Froude's law or the law of comparison. His studies were first made with miniatures and then verified by the towing of a large vessel formed on identical lines.

Within the last twenty years there have been created and developed many vessels of novel types and the results obtained would have been virtually out of the question but for the model tank. Millions of dollars would have been wasted in blind groping instead of obtaining positive assurance of what the finished vessel would do before a single cent was spent in her building.

One illustration will suffice. Among the vessels in the naval review is the gunboat Nashville, designed in 1894. She has a displacement of about 1,375 tons and, with 2,500 horse-power, makes sixteen knots. Last year the model tank developed the hull form for the gunboat Sacramento, a vessel of 800 tons more displacement, but of a speed of sixteen knots upon a development of only 2,000 horse-power. This saving of 500 horse-power, calculated at $60 a horse-power, meant an economy in first cost of machinery of $30,000; but it also meant that the larger gunboat could be driven at a speed equal to her smaller sister ship. Upon 800 tons the bigger Sacramento could carry a more powerful armament, go further upon the same supply of fuel and be more weatherly in stormy seas; in brief, be a much better unit of the fleet. And all of this was made certain by the expenditure of a few hundred dollars for wooden models and their testing, the lines of the hull being altered during these tests until the best length and shape were obtained.

All of the models tested at Washington are of a uniform length of twenty feet, and the purpose of making them so large is to reduce the possible error in translating the performance figures of the model into those of the full sized vessel. These models are made of wood and are fashioned in a machine especially designed for this work.

Next the model is painted and carefully varnished, in order to obtain a very smooth surface; and with this done various waterlines are marked upon the white paint, so that instantaneous photographs taken during the towing tests will show just how and where the waves and the hollows produced by the miniatures in motion are developed.

When the model is ready it is carried to the basin and there loaded in the balancing tank with bags of shot until it has the right weight or displacement and proper trim or poise upon the water. With this done it is ready to be attached to the towing carriage and tested.

The towing carriage is a sort of mobile bridge which straddles the main tank and it is driven by electricity, the different speeds being under very nice control. Upon the towing carriage are all of the operative switches and measuring instruments and also the recording mechanism which marks the speed of the model and its pull or resistance when drawn through the water. The aim is to obtain a ship form which will show the least pull or resistance at the desired maximum velocity. The actual speed of the model is a mathematical ratio of the relation between this miniature and the full sized ship, and therefore the model does not travel fast if you consider what the big craft will really do.

The towing basin is 370 feet long and 48 feet wide, and the maximum speed of the carriage is relatively far in excess of the probable speeds of anything but freak craft.

After a model of satisfactory form has been developed and tested, then comes the further task of making the figures of the trials applicable to the intended ship.

Now there is just one part of this work which does not follow Froude's law of comparison. This is the factor of the friction set up between the water and the wetted surface of the vessel's underbody. This resistance follows a law of its own and it is necessary to tow another model which consists of a thin plate just as long as the small craft and with a submerged surface exactly equal to that of the model.

From these two tests, that of the plane and that of the model, the designer has the information he wants and this information covers various trials over a wide range of speeds, so that the naval architect knows both the maximum and the cruising speeds at which the vessel can be propelled most economically. The cruising speed is an important one, because it is at this rate of travel that ships of war go most of the time. Full speed is really a battle reserve or something to be called for only when urgency demands. In this particular, fighting ships differ radically from the ocean greyhound of commerce.

But don't think that the naval designer has an easy task even with the model tank at his disposal. The speed trials of the full sized ships are no less important to him because they give him a check upon his model work. This check is very necessary inasmuch as it enables the designer to bridge over the gap between his model and the real vessel year by year with more exactness.

The builder of the hull structure, the naval architect or naval constructor, has only a share in the final product. The naval engineer must take up the problem where his brother ends. That is to say, the engineer knows just what energy his propellers must exert effectively against the water in order to force the ship along at her several speeds. He, too, must work from the outside of the ship inward up to a point.

The position of the propeller in relation to the hull and the very form of the propeller must be suited to the particular craft in question. These can be tried in miniature in association with the model for the determination of some data, but after that the engineer must draw upon experience and his carefully tabulated records of other performances.

The average annual expenditures for the maintenance of the model basin at Washington are under $25,000, and this is a trifling sum compared with the savings which have been effected through careful designing. In the case of the three scout cruisers Birmingham, Chester and Salem by merely lengthening their hulls it was found possible to save in those three ships a combined total of 17,000 horse-power over that required for the original design. Figured at $60 a horse-power this represented an economy of machinery cost amounting to $1,020,000.

The model experimental basin is no longer looked upon as an investment of doubtful value; every first class naval power has one of these establishments, and like that at Washington most of them lend their aid to the merchant marine as well. Such is the development of private experiments which Dr. William Froude began, so to speak, in his own back yard. All of the successful ships of to-day are indebted to his pioneer work.

Process of Powder Manufacture

Making Gun Cotton

Scenes Illustrating the Manufacture of Smokeless Powder

Smokeless Powder at an Important Stage

The Actual Forming of the Powder Grains

WHEN the United States fought Spain fourteen years ago most of the American ships used a kind of powder which soon fouled the guns, always made great clouds of acrid smoke, and not infrequently completely shut out the target from sight. Bad as these things were, there were other defects in the brown powder then used that were even more objectionable. Only about half of the charge did useful work, and its manner of functioning put a decided limit upon the power of any gun and its range and impaired its accuracy as well.

Brown powder was merely a modified form of black powder, and was a mechanical mixture of sulphur, saltpeter and charcoal. The smokeless powder now used is a chemical metamorphosis of cotton, and, contradictory as it may appear, its development has not been inspired primarily by the one desire to get rid of smoke as smoke.

Even the layman knows that smoke represents incomplete combustion, particles that could be burned profitably if properly inflamed, and the ordnance engineer knew that 50 per cent. of the brown powder was wasted in getting the other half to work. His problem was to find a powder that would yield a higher measure of efficiency while incidentally eliminating or reducing some of the other disadvantages involved in the use of brown powder. It took a deal of searching and some more or less disastrous experimenting before smokeless powder as it is known to-day was evolved.

The base of smokeless powder is guncotton, and guncotton is nothing more or less than cotton steeped in nitric acid. This operation transforms the cotton into an explosive which burns smokelessly, quickly, and without violence in the open, yet detonating with tremendous energy when struck. In these particulars you see how different guncotton is from gunpowder as commonly understood.

Cotton the Basis of Navy's Smokeless Powder—Great Guns' Efficiency Vastly Increased by Ammunition Improvement

The comparative smokelessness of smokeless powder is only one of its good points. Formerly, the guns were designed to suit the powder, and this hampered the engineer and limited the military possibilities of the weapon; to-day the rifle is planned to do certain things and then the smokeless powder grains, in their turn, are formed to suit the gun. This is, indeed, a revolutionary change and upon it hinges the biggest share of gunnery advance which has been made in the last decade—an advance which the public but half realizes at best. We have got rid of nearly all of the smoke; the guns are no longer fouled by the discharge; a vastly increased ratio of efficiency has been obtained pound for pound of the propellant; and, best of all, the powder cooperates with the gun builder in carrying the shell further and more forcibly toward the steel clad sides of a foe.

The navy's powder factory is at Indian Head, Md. Waste from the looms of cotton mills is the material commonly used. After being cleaned, this waste is put in drying rooms where the temperature is that of the boiling point of water. The purpose of this drying is to increase the absorptive tendency of the cotton when afterward steeped in the nitric acid. In air tight cans the dried cotton is taken to the nitrating house and dumped into a vat containing a mixture of nitric and sulphuric acids. The purpose of the sulphuric acid is to absorb the water given off by the so-called dry cotton waste due to the reaction of the nitric acid. This leaves the nitrating bath unimpaired so that it can do its metamorphosing work well.

After soaking a few moments in the acid the cotton is tumbled into bins and roughly washed to smother any tendency toward acid burning. It has now become guncotton or pyro as it is familiarly called at the works, and constitutes the crude base for smokeless powder. Acid has been used to change its chemical nature, and, having done that, the immediately succeeding operations are to get rid of all free acid—leaving only the transformed cellular fibre of the cotton.

Without entering into the technicalities of chemistry, it is an important fact that guncotton becomes soluble in a mixture of ether and alcohol provided the strength of the nitrating bath does not exceed a definite percentage. For the purposes of smokeless powder, the guncotton must be soluble, and when mixed with the ether and alcohol and subjected to pressure it is changed into an elastic, plastic substance capable of being moulded into powder grains or units. Later when the major part of the helpful solvent has been extracted, the stuff becomes hard, semi-translucent and not unlike brown taffy in appearance. This is its state when ripe for food for guns.

After its acid bath, the pyro is put in steaming tanks where it is stewed for a couple of days in an effort to get rid of more of the free acid. This does not answer completely, however, and the following treatment is needed.

There is a duplicate at Indian Head of the pulping plant of a paper mill, and into that the pyro goes for a thorough mincing and cleansing, coming out after thirty hours in the form of a white paste quite free of objectionable acid. It is upon the perfection of this outcome that the chemical stability of the powder later on depends.

Of course, the pulpy pyro is full of water; this must be eliminated, and the next treatment, after a preliminary rough squeezing, is to accomplish this. For this operation it is carried to the dehydrating house, where the water is expelled by the dual action of alcohol and pressure.

Now alcohol is one of the ingredients of the needful solvent, so all that is next necessary is to add the ether and knead the stuff in a machine which is a mechanical double of the bread mixer of the modern steam bakery. The pyro has now become a colloid—a kin of celluloid—and chemically the powder is finished. But other things have yet to be done to the colloid before it is ready for the guns.

The stuff is next squeezed in presses several times to make its substance homogeneous, and then it passes to the powder forming machine. There the plastic colloid is forced through dies, whence it issues in the shape of an elastic rod with longitudinal passages reaching from end to end. This rod is chopped off by a cutter into small lengths or cylinders, which are the grains, so called, of this modern propellant.

In this state the powder is green or unfit for service because it contains too much of the volatile solvent. In order to get rid of most of this the grains are removed to the drying house, but the ether and alcohol are not allowed to escape into the free air. By means of a distilling apparatus the solvent is largely withdrawn and saved so that it can be again used for the making of other powder. This is one of the economies due to progress. Afterward the grains are further dried and when at the right stage are stowed in air tight metallic cylinders after being packed in bags. This is the manner in which it is held in readiness within a ship's magazines.

But before the powder can leave Indian Head every lot, every batch of grains made from a certain quantity of ingredients, must be tested thoroughly. If the propellant shows any undesirable signs then it must be further treated or made over.

This is one of the remarkable characteristics of smokeless powder. While our smokeless powder is now said to be stable or serviceable for a term of ten years, still it may become too "quick" before then by the complete escape or the reduction of the solvent purposely left in it to check the speed of ignition. When this is discovered to be the case the powder is sent back to Indian Head, and there at a very moderate outlay it is remade into a first class propellant. This could not be done with either black or brown powders after they had become deteriorated in any way.

Temperature is the agent which works most of the change in powder after it has passed into service. Therefore the temperature of the magazines on shipboard is kept below a prescribed maximum. At Indian Head there is a house, called the surveillance magazine, where samples of every lot of powder manufactured are kept.

Each type of gun has its own powder. The size and form of the grains are made to suit, and this makes safely possible velocities which otherwise would be quite out of the question upon a given weight of gun. The powder units are so fashioned that they will burn progressively and completely before the projectile passes out of the muzzle of the weapon. The propulsive gases are generated first quickly in that part of the gun which is made strong enough to meet this sudden stress, and then they are produced just fast enough, but with decreasing pressure, so that they can speed up the shell increasingly thence to the very muzzle. In this work the holes through the grains play an important part, because they regulate the quickness with which the gases are given off.